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From the Editors

By coincidence, the bulk of papers presented in this issue focus attention on species found in watery environments. Gillespie, McNabb and Gabarov report on the Large Brown Tree Frog in Victoria; and Short and Osborn describe differences in frog populations on the basis of calls heard over a long time period. Because frogs are important indicator species, both these papers have added importance, as they help to increase our understanding of frog populations.

The paper by Vafiadias on *Sepia apaman* and that by Murphy on *Chelodina expansa* have importance also, in recording first occurrences of these species in their respective localities.

The significance of the reflective note by Alan Reid is primarily historical. It was delivered as an address at a recent event to mark the 20th anniversary of the FNCV's tenure in Gardenia Street, Blackburn. As pictured in the photograph accompanying this note, Alan was the Guest of Honour at the official opening of the building, in July 1996. Thus he was well placed to reflect on the importance of the latter event.

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The

Victorian Naturalist

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Front cover: The Large Brown Tree Frog *Litoria littlejohni*. Male from Morton National Park, New South Wales. Photo Graeme R Gillespie. See page 128.
Back cover: Striped Marsh Frog *Limnodynastes peronii*. Rowville, Victoria. Photo Anne Morton.

The biology and status of the Large Brown Tree Frog *Litoria littlejohni* in Victoria

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Abstract
The Large Brown Tree Frog *Litoria littlejohni* is one of several poorly known threatened amphibian species in Victoria. We report recent findings on *L. littlejohni*, assess its current conservation status in Victoria, review information on its biology and identify potential threats that may have contributed to its apparent decline. Extensive searches in recent years have located *L. littlejohni* at only four sites in East Gippsland, suggesting that this species has undergone a severe decline. Threats to this species include timber harvesting and associated forest management practices, changed fire regimes and infection by the amphibian fungus *Batrachochytrium dendrobatidis*. In 2014, the Victorian Government released a Flora and Fauna Guarantee Action Statement for *L. littlejohni*, intended to ensure conservation of the species; inadequacies in the Action Statement are identified. (*The Victorian Naturalist* 133 (4), 2016, 128–138)

Key words: Threatened species, *Litoria littlejohni*, logging, chytrid fungus, amphibian declines

Introduction

Since the late 1980s, many amphibian species have suffered major population declines, both globally and within Australia (Blaustein and Kiesecker 2002; Stuart *et al.* 2004). Many factors have been implicated in these declines, including habitat loss and degradation (e.g. Gillespie and Hollis 1996), introduced predators (Gillespie 2001; Beebee and Griffiths 2005), emergent disease (Berger *et al.* 1998), pesticides and chemical pollutants, and climate change (Beebee and Griffiths 2005). Within Australia, at least three species may have become extinct and a further 37 species have undergone population declines and range contractions over the past 30 years, warranting their inclusion on the IUCN Red List of Threatened Species (Hero *et al.* 2006).

The Large Brown Tree Frog (or Heath Frog or Littlejohn's Frog) *Litoria littlejohni* (front cover), is the largest member (snout–vent 60 mm) of the *Litoria ewingii* species complex, a group of morphologically similar species, with similar reproductive biology, that occurs in south-eastern Australia (Martin and Littlejohn 1966; Anstis 2013). It occurs on the coastal fall of the Great Dividing Range from the foothill forests of East Gippsland, north-east of Bairnsdale, to the Watagan Mountains near Wyong in central NSW, from 100 to 1160 m above sea level (Atlas of Living Australia (ALA 2015); Victorian Biodiversity Atlas (VBA 2015). There is a notable range disjunction between the Victorian border and the latitude of the ACT; however, recent genetic analysis does not indicate any corresponding genetic disjunction (S Donnellan, South Australian Museum, unpublished data).

Litoria littlejohni is considered a rare and poorly known species (e.g. Opie *et al.* 1990; Lemckert 2004a), and no specific ecological studies on it have been undertaken. The lack of records, combined with reports of declines in parts of its range (e.g. Mahony 1993), have resulted in its listing as *Vulnerable* under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Endangered* on the Victorian Government list of threatened vertebrates (Department of Sustainability and Environment 2013), *Threatened* in Victoria under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act), and *Vulnerable* under the *Threatened Species Conservation Act 1995* (NSW). It has been recorded from 48 localities in Gippsland, Victoria (Fig. 1) between Mount Elizabeth, north of Bruthen, and the Victorian border north of Mallacoota. Records have accumulated in two general ways: by various university and museum biologists working across Victoria in the early parts of the 20th century through to the 1970s, and via biodiversity surveys undertaken by government agencies, mostly as part of the pre-logging survey program between 1982 and 1992 (e.g. Chesterfield *et al.* 1988; Opie *et al.* 1984, 1991; Westaway *et al.* 1990; Lobert *et al.* 1991) (Fig. 2). The extent of collections and surveys undertaken in Victoria provides a general overview of the historical distribution of the species. However, broad-based biodiversity surveys ceased with the termination of the pre-logging survey program in 1992. Since then, no formal targeted surveys or monitoring of populations of *L. littlejohni* have taken place, although there have been surveys for other threatened frog species, overlapping with part of the range of *L. littlejohni* (e.g. Holloway 1997; Gillespie *et al.* 2014).

Powell and Sedunary (2013) found no *L. littlejohni* during pre-harvest surveys of threatened species in 100 logging coupes in Victoria over a one-year period. However, information vital to the interpretation of this report is lacking: (i) locations of the coupes were not provided, so it

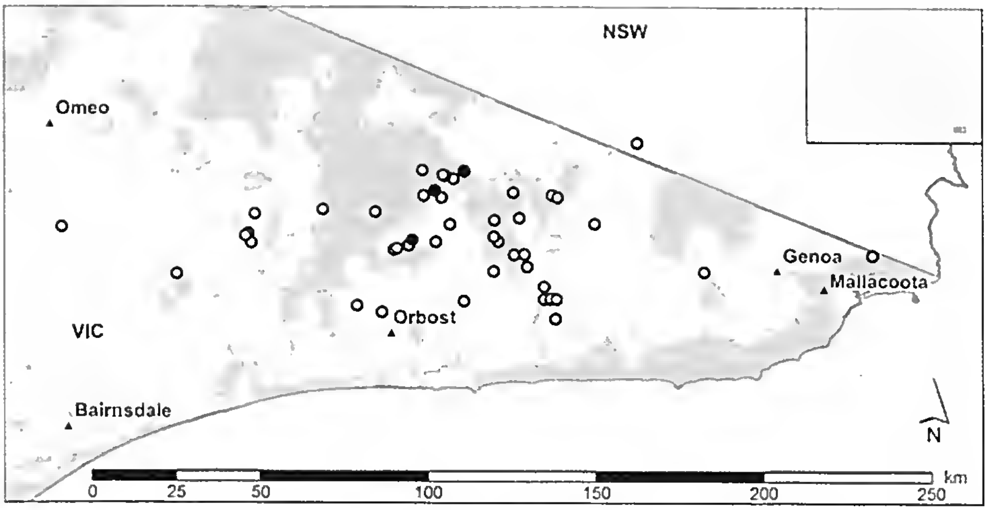

Fig. 1. Distribution of *Litoria littlejohni* in Victoria. Open circles = historical records; solid circles = recent (2015) records. Dark shading indicates protected areas.

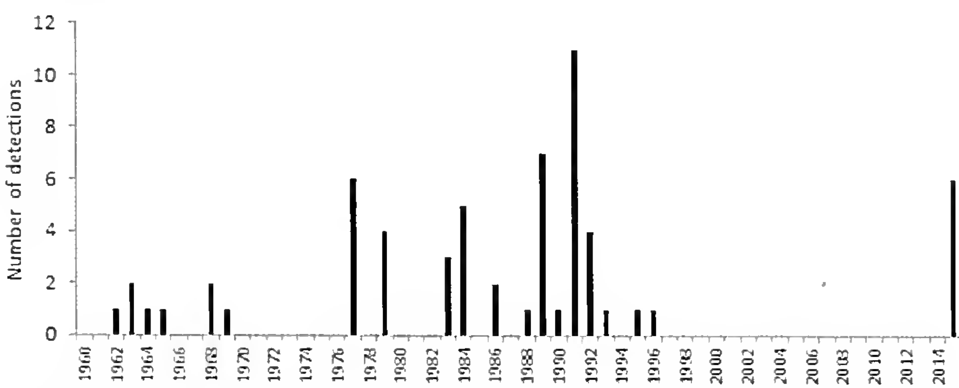

Fig. 2. Annual number of observations of *Litoria littlejohni* in Victoria. Each observation represents detection of the species (adults, tadpoles or eggs) at any location in one year, not actual numbers of individuals detected. Information is derived from Martin and Littlejohn (1966), VBA (2015) and present study.

is not clear how many of them were within the potential range of this species; (ii) no information on survey methods, timing or sampling effort for frogs was provided so it is not possible to assess the adequacy of sampling; (iii) specifically who undertook the surveys is not reported, except that they were commercial consultants. There are doubts about the rigour and reliability of such consultants undertaking threatened frog surveys in Gippsland (see Urlus and Marr 2011; Clemann and Gillespie 2012).

We report on the findings of recent surveys for *L. littlejohni* in Victoria, and review and synthesise current information on the species. We then assess the conservation status of *L. littlejohni*, review threats to its survival, and discuss the management implications of our findings.

Methods

Rather than making a formal systematic survey, we collated information from an aggregate of surveys and opportunistic searches for *L. littlejohni* in the years 2009–2015. Between 2009 and 2015, we visited most historical localities for *L. littlejohni* in Victoria, identified in the VBA. Where possible we located the specific water body at which the species had historically been recorded, or sampled all water bodies that could be located within the general vicinity of the historical record. Lentic water-bodies, rather than streams, were targeted, since all Victorian records of the species have been in association with the former (Martin and Littlejohn 1966; Chesterfield *et al.* 1988; Opie *et. al.* 1984, 1990; Lobert *et al.* 1991; G Gillespie pers. obs.). Up to four repeat visits were made to 12 historical sites over the six-year period. Additionally, we sampled numerous water bodies, including 'fire dams', roadside ditches and swamps, within the general historical range of the species, in habitats similar to those in which it has previously been reported. At each site, we listened after dark for frog calls for between 10 and 30 minutes; the call has been well described, and recordings of the call are readily available, hence we are confident of correct identification of the call in our surveys. Night-time visual surveys of water body perimeters and surrounding vegetation were undertaken with a headlamp. At 29 historical sites (surveyed by GG), tadpoles were sampled by dragging a 30 cm-wide dip net through the water body at least five times. Most tadpoles were identified using Anstis (2013). All sampling was undertaken from March to November, and most sites were visited after rain, in conditions believed most suitable for detecting the species. Most tadpole sampling was undertaken between September and December, months in which *L. littlejohni* tadpoles had historically been encountered (G Gillespie pers. obs.).

Results

Forty-four historic *L. littlejohni* sites were resampled, along with a further 204 sites within the general range of the species. Adult *L. littlejohni* were found at six different water bodies across four localities in East Gippsland (Fig. 1). The specific details of the localities are not disclosed here to minimise risk of disturbance. In all cases, confirmation of identification of *L. littlejohni* was made by capture of adults (Table 1). Calling males were detected at all sites; females were detected at three sites, in amplexus with males on two occasions, and egg masses were detected at the same sites as females. Tadpoles similar to those of *L. littlejohni* were observed at one site (locality 6) but their identification was not confirmed.

The following species were also detected at various localities surveyed: Common Eastern Froglet *Crinia signifera*, Haswell's Froglet *Paracrinia haswelli*, Green and Golden Bell-frog *Litoria aurea*, Bleating Tree Frog *Litoria dentata*, Brown Tree Frog *Litoria ewingii*, Blue Mountains Tree Frog *Litoria citropa*, Lesueur's River Frog *Litoria lesueuri*, Leaf-green Tree Frog *Litoria nudidigita*, Peron's Tree Frog *Litoria peronii*, Whistling Tree Frog *Litoria verreauxii verreauxii*, Banjo Frog *Limnodynastes dumerilii*, Striped Marsh Frog *Limnodynastes peronii*, Smooth Toadlet *Uperoleia laevigata* and Martin's Toadlet *U. martini*. These data have been lodged with the VBA.

Discussion

Habitat associations

Within Victoria *L. littlejohni* has been found mostly in Wet Forest, followed by Damp Forest and Warm-temperate Rainforest, Montane Forest, and on occasion Shrubby Dry Forest (Martin and Littlejohn 1966; Chesterfield *et al.* 1988;

Table 1. Summary of *Litoria littlejohni* detections and activity observed at each locality in 2015.

Locality	Date	Habitat	Males	Females	Calling	Eggs
1	5 April	Road culvert Wet Forest	1		yes	
1	12 April	Road culvert Wet Forest	1		yes	
1	18 April	Road culvert Wet Forest	1		yes	
2	21 April	Road puddle Wet Forest	1		yes	
3	16 September	Roadside ditch Damp Forest	1		yes	
4	16 September	Roadside ditch Damp Forest	4	1	yes	yes
5	9 September	Hollow log Damp Forest	4	2	yes	yes
6	9 September	Hollow log Damp Forest	6	1	yes	yes

Opie *et al.* 1990, 1984; Lobert *et al.* 1991; G. Gillespie pers. obs.; see Department of Conservation and Natural Resources (DCNR) (1995) for descriptions of these ecological vegetation types). In NSW, to the north of the distribution disjunction, the species has been reported from wet and dry sclerophyll forests with rocky outcrops (Barker *et al.* 1995), high-elevation woodlands in the Sydney area (Griffiths 1997), and coastal woodland and heath (White *et al.* 1994; Anstis 2013). The species typically occurs along the sandstone escarpment woodland and heathland habitats, as well as the coastal plains near Sydney (White and Ehmann 1997; Lemckert 2004). The species appears to use different habitats in NSW than in Victoria, and may also occur in a wider range of natural vegetation types in NSW. It has never been recorded from cleared habitats, such as farmland or forestry plantations.

Almost all records represent breeding sites at which males have been heard calling or tadpoles have been located. In Victoria all breeding sites have been lentic natural and man-made water bodies: rain-filled pools created by upturned tree stumps, rain-filled pools in logs, flooded old mine shafts, gravel pits, forest fire-dams, and roadside ditches (Martin and Littlejohn 1966; Chesterfield *et al.* 1988; Opie *et al.* 1984, 1990; Lobert *et al.* 1991; G Gillespie pers. obs.). In contrast, approximately 30% of breeding records in NSW have been along streams (Lemckert 2004a).

Many amphibians are less detectable outside their breeding seasons, when males are not calling and individuals are more dispersed (Wells 2007). *Litoria littlejohni* has rarely been found when not breeding, or away from breeding locations, suggesting that it resides only temporarily in the vicinity of breeding sites and otherwise disperses into the surrounding forest. The lack of records away from breeding sites may reflect an inherently low population density, cryptic behaviour (such as limited activity patterns), or use of habitats that limit detection, such as in the forest canopy. Apart from ecological vegetation classes, which describe broad habitat types, the microhabitats used by *L. littlejohni* are unknown, as are dispersal capabilities, home range sizes and sheltering sites (Hero *et al.* 2002; Lemckert 2004a).

Reproductive biology

Anstis (2013) reported that most calling and breeding activity occurs in late winter and spring. Using records predominantly from NSW, Lemckert (2004a) identified a higher frequency of calling activity in February than in other months, but acknowledged that survey data for winter months were scant. In Victoria, calling has been heard sporadically throughout the year, often during or after rain; however, most calling has been heard in February and October (Fig. 3). Tadpoles have been found between September and March (Fig. 3), but egg-laying has also been observed in April (G Gillespie pers. obs.), so it is likely that tadpoles

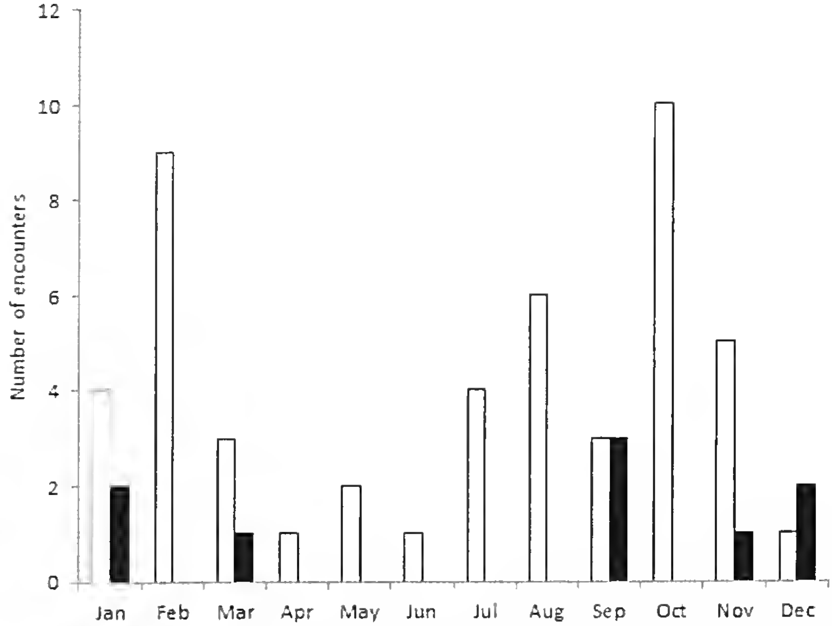

Fig. 3 Number of individual occasions on which *Litoria littlejohni* has been heard calling (open bars) and tadpoles and/or eggs have been located (solid bars) in Victoria.

could be found during autumn and winter months as well. As there has been no systematic monitoring of breeding phenology of this species, it is not possible to identify peak breeding activity periods with any confidence.

Clusters of up to 70 eggs have been reported for *L. littlejohni* (Anstis 2013), but it is not known whether or not these clusters represent the full egg complement of a single female. Female frogs of some other species are known to spread their eggs among different localities and mates, strategies thought to increase offspring fitness and survival (Wells 2007). Given the temperate distribution of *L. littlejohni*, females are likely to produce only one clutch per year (see Wells 2007).

Tadpoles are free-swimming (Anstis 2013) and metamorphosis has been observed in Victoria in November and January (G Gillespie pers. obs.) and March (Martin and Littlejohn 1966). Anstis (2013) provides a detailed description and illustrations of the tadpoles of *L. littlejohni*; however, in Victoria it is not possible to reliably distinguish them from those of the Whistling Tree Frog *Litoria verreauxii verreauxii* (G Gillespie pers. obs.).

Historical and current status in Victoria

The historical surveys and earlier collections of *L. littlejohni* in Victoria had several limitations: Historical collections were often opportunistic, and invariably restricted to the vicinity of road access.

Pre-logging fauna surveys were not systematic for broad biodiversity assessment; survey areas were determined by timber harvesting priorities, and thus were biased. Not all places where the species potentially occurred were sampled.

Seasonal timing and sampling effort were not consistent between surveys, nor were sampling techniques and sampling effort standardised between surveys or staff. For instance *L. littlejohni* may breed mostly in autumn or early spring, whereas surveys were typically undertaken between October and March, thus reducing likelihood of detection.

Surveys were of low intensity with no replication, and were inadequate to confidently assess occurrence of rare or cryptic species. The necessary sampling effort to reliably detect *L. littlejohni* at a site is unknown. Lemckert (2004a) repeatedly visited previously confirmed calling sites for this species in NSW during seemingly suitable conditions, but detected the species on only 30% of occasions.

Consequently, available data on *L. littlejohni* indicate only where and when the species was previously found, rather than providing an accurate picture of where the species does and does not actually occur now or in the past. Historical data also do not provide any information on population sizes or trends during or since those detections.

The historical surveys do provide some detection data that can be compared with other frog species in Gippsland, and indicate that *L. littlejohni*, along with the Giant Burrowing Frog *Heleioporus australiacus* (Gillespie 1990) and the Stuttering Frog *Mixophyes balbus* (Gillespie *et al.* 2014), were relatively rare, cryptic or both, since many other species known from Gippsland were detected concurrently far more frequently and in greater numbers. Similar conclusions have been drawn from observations in NSW (Lemckert 2004b). However most historical formal fauna survey work in Victoria was not targeted at frogs, let alone designed to optimise detection of rare and/or cryptic species such as *L. littlejohni*, which may have had activity patterns that overlapped poorly with the survey seasons and methods employed. Consequently these historical surveys probably underestimated the occurrence of *L. littlejohni* at that time.

In contrast, our recent surveys were targeted at known historical sites and known suitable habitat, timed to coincide with seasons and climatic conditions likely to maximise detection, and employed sampling techniques suitable for detecting various life-stages of *L. littlejohni*. Despite sampling a large number of sites in this way, we found the species at only four localities. This strongly suggests that *L. littlejohni* has suffered a substantial decline throughout its historical Victorian range. Several other amphibian species have suffered marked declines or disappeared in the region since the late 1970s and 1980s, including the Green and Golden Bellfrog *Litoria aurea* (Gillespie 1996), Spotted Tree Frog *L. spenceri* (Gillespie and Hollis 1996), Baw Baw Frog *Philoria frosti*, Southern Corroboree Frog *Pseudophryne corroboree* (Osborne *et al.* 1999), and Southern Barred Frog *Mixophyes balbus* (Gillespie *et al.* 2014). Recent records of two other species in the region are also scant—*Heleioporus australiacus* (Bilney *et al.*) and *Uperoleia martini* (Department of Environment, Land, Water and Planning [DELWP] 2015)—and it is plausible that they have also undergone decline. Our findings are therefore consistent with this broader pattern of probable decline. However, adequate resources have not been allocated to assess this pattern, and targeted surveys and monitoring are an urgent priority.

Threats

Several factors threaten *L. littlejohni* in Victoria and may have contributed to its decline. Whilst some records of *L. littlejohni* were in national parks, most were from production forest areas (i.e. areas that are available for logging). Extensive areas of *L. littlejohni* habitat have been, and continue to be, logged. Clear-fell logging has been shown to have long-term detrimental effects on temperate amphibian populations and communities (Bury and Corn 1988; Corn and Bury 1989; deMaynadier and Hunter 1995). Concerns about impacts of logging and associated forest management on *L. littlejohni* were raised by Lobert *et al.* (1991); however, no studies have been undertaken to evaluate these impacts. Assessing impacts of forestry activities on amphibians is difficult, due to their complex lifecycles and confounding environmental and historical land management factors (Gillespie and Hollis 1996; Goldingay *et al.* 1996; Gillespie and Hines 1999; Gillespie 2002). Nevertheless, the following evidence suggests that forestry operations are highly likely to adversely affect *L. littlejohni*:

- The species is dependent upon forest habitat for its survival.
- Most historical localities of *L. littlejohni* are in timber production areas. Most of the known habitat of *L. littlejohni* in Victoria has now been logged or fragmented by forestry operations (DCNR 1995).
- Most frog species are adversely affected by significant changes to their habitats (Gillespie

et al. 2011). *Litoria littlejohni* does not thrive in highly disturbed environments, as evidenced by its absence from areas cleared of native vegetation, plantations or intensive silviculturally managed forests. Logging grossly alters its habitat by changing forest structure, light penetration levels, moisture and temperature regimes, all of which have been shown to adversely affect amphibians (deMaynadier and Hunter 1995; Gardner *et al.* 2007). Amphibians are ectotherms and have a moist skin for gas exchange, which also plays an important role in water balance and biochemical defence (Duellman and Trueb 1994; Wells 2007). They therefore tolerate narrower temperature ranges than most other vertebrates, and are more sensitive to changes in levels of environmental moisture (Duellman and Trueb 1994; Wells 2007). Consequently, factors that significantly alter these regimes are likely to adversely affect frogs, including *L. littlejohni*.

- Arboreal forest frog species typically exploit tree hollows, exfoliating bark, fallen logs and leaf litter for shelter (Duellman and Trueb 1994; Wells 2007). Logging removes and alters these sheltering sites that are important for avoiding predators and maintaining temperature and hydration. Logging may affect food availability and the abundance of predators, as these species are also affected in various ways by changes in habitat brought about by logging (see Lindenmayer and Burgman 2005).
- Increased water temperatures and evaporative rates in newly logged areas may reduce the viability and availability of natural breeding habitats for *L. littlejohni*. Man-made lentic water bodies have been created throughout Gippsland forests, either deliberately or inadvertently, as part of forest and road management activities (G Gillespie pers. obs.). Hundreds of 'fire dams' have been excavated throughout the region to increase water availability for fighting fire. Borrow pits, quarries, culverts and diverts, resulting from the construction of thousands of kilometres of forest access roads, often retain standing water for considerable periods of time. *Litoria littlejohni* may have relatively general breeding habitat requirements, as it has been observed breeding in man-made water bodies created through forest management activities (G Gillespie pers. obs.). However, the comparative reproductive success in natural and artificial water bodies is unknown. Artificial water bodies may serve as 'ecological traps' through elevated drying rates or predation rates (deMaynadier and Hunter 1995). Other generalist species may also be able to exploit these habitats more successfully and out-compete *L. littlejohni*. One generalist species, *Crinia signifera*, is particularly attracted to such artificial water-bodies (G Gillespie pers obs.) and it is a reservoir host for the amphibian chytrid fungus *Batrachochytrium dendrobatidis* (Hunter *et al.* 2010, Scheele *et al.* 2015). Consequently these artificial water bodies cannot be considered an 'offset' for other detrimental impacts on the species' habitat.

Litoria littlejohni may be detrimentally affected by changes resulting from one or more of the above forest management activities. Logging may result in fragmentation of suitable habitat and isolation of populations over time.

Whilst fire is a natural phenomenon in temperate Australian forest ecosystems, it is increasingly used as a tool to manage forests. Fuel-reduction burning in Victoria is undertaken primarily to protect human life and private and commercial assets, rather than to maintain natural fire regimes, including those in protected areas. Frogs have little defence against fire; they are slow and sedentary and cannot flee from fire (although some burrowing species may survive initial fire if they are already underground or able to retreat rapidly to their burrows). They also have low tolerance of extreme temperatures and desiccation. Non-burrowing species that do survive fire probably do so by sheltering in large logs or patches of unburnt forest. *Litoria littlejohni* is therefore potentially sensitive to unnatural fire regimes (Daly and Craven 2007). Its restriction to forest types that burn infrequently, and rarely with high intensity, may reflect an inability to cope with frequent or high-intensity fire. However, when these forests are logged they are subjected to a coupe burn to clean up the slash and stimulate regeneration. Coupe burns in Victorian forests are typically hot fires, which are likely to destroy any remaining refugia for *L. littlejohni*.

In 2013, bushfires burnt large areas of the range of *L. littlejohni* and are likely to have adversely affected the species, further increasing uncertainty about its current population status.

The amphibian fungus *B. dendrobatidis* has been implicated in the extinction of several species of Australian frogs, and population declines in numerous other species (Berger *et al.* 2009). The disease is widespread across temperate, montane and wet tropical parts of Australia (Berger *et al.* 2009). Although not confirmed, it is highly likely that *L. littlejohni* has been exposed to this pathogen. Conspecifics of *L. littlejohni,* such as the Alpine Tree Frog, *Litoria verreauxii alpina*, have been adversely affected by *B. dendrobatidis* (Clemann *et al.* 2009).

Other factors that facilitate spread of disease or stressors, that reduce the ability of frogs to cope with infection, may exacerbate its effects. For instance, there is increasing evidence that some common 'ecological generalist' frog species may be hosting and spreading *B. dendrobatidis* (Hunter *et al.* 2010; Scheele *et al.* 2015). Some ecological generalist species benefit from habitat disturbance. Forestry operations, and associated road network construction that facilitate the dispersal of these species, may therefore promote the spread of this pathogen.

South-eastern Australia has been subjected to protracted drought conditions throughout the last 15 years (van Dijk *et al.* 2013). Given its association with moist forest types, and its use of ephemeral rain-filled water bodies to reproduce, *L. littlejohni* may have been adversely affected by the low rainfall and seasonally high temperatures during the drought. Drought has affected its entire range, with potential interactive effects with forest management practices, such as greater evaporative effects, increased temperature regimes causing physiological stress, reduced availability of breeding sites, or increased frequency and extent of wildfire. The frequency and severity of droughts (Kirono *et al.* 2011) and fires (Flannigan *et al.* 2009) are predicted to increase with climate change, resulting in profound impacts on biodiversity. Elevated mortality due to heat or water stress (or disease), or poor reproductive success due to reduced availability of suitable breeding habitats, may have resulted in a decline in abundance and contraction of distribution to optimal refugia within the species' range (e.g. Scheele *et al.* 2014b). Based upon the known ecological characteristics of the species, mature moist forest types potentially provide important refugia during times of environmental stress. Yet the remaining pockets of mature moist forest in Gippsland continue to be targeted for timber harvesting.

Conservation implications

The apparent severe decline of *L. littlejohni* and the known existence of only four extant localities in Victoria warrant a careful review of the conservation status of this species. Furthermore, since nearly all known records are more than 20 years old, the current distribution of the species is effectively unknown, making it impossible to derive confident inferences about the adequacy of the current reserve system in offering conservation protection for the species.

The steps for addressing declining species are well established and accepted (see Caughley and Gunn 1996), and should apply to *L. littlejohni* as follows:

1. Undertake surveys with appropriate methods to determine with precision the current distribution and spatial, temporal and demographic characteristics of the observed decline.
2. Identify the species' breeding and non-breeding habitat requirements, and evaluate factors influencing the quality and availability of suitable habitat across its distribution.
3. Identify measures required to protect enough suitable habitat to ensure the species' viability in the wild. Since some information is already known about habitat requirements, interim measures could be put in place immediately to protect known habitat throughout the putative range of *L. littlejohni* in order to counter any further declines.
4. Identify all potential threatening processes that may have affected the species' distribution and abundance, then properly evaluate the relative contribution to the decline and impediment to recovery.
5. Identify measures to mitigate the impact of key threatening processes, once identified.

6. Implement an appropriate monitoring program to evaluate the success or otherwise of these measures, and modify as necessary.

The actions needed to achieve these steps are typically documented in a Recovery Plan, or an Action Statement in Victoria. In 2014, the Victorian Government released a *Flora and Fauna Guarantee* Action Statement for *L. littlejohni* (Department of Environment and Primary Industries 2014). The 'Intended Management Actions' outlined in the Action Statement generally follow the steps identified above; however, this plan has several major shortcomings.

The Action Statement states (p. 4) that 'all known and discovered populations should be considered important until such time as rigorous investigations indicate that they are not'. Based upon current information, this should encompass all existing records, until it can be demonstrated that they are less important than those in other areas. However, no sites are identified for any specific protection measures from any of the listed threatening processes.

The Action Statement identifies the need for surveys to ascertain the species' current distribution and status. However, no surveys have yet been undertaken. Most of the subsequent actions and objectives of the Plan are contingent on this action, and therefore cannot be implemented until such surveys are undertaken. As is the case for almost all threatened frogs in Victoria, no funding has been allocated to survey and monitoring for *L. littlejohni*, nor for recovery and management actions for this species.

The Action Statement identifies a Special Protection Zone (SPZ) prescription, whereby a 28 ha buffer from timber harvesting will be prescribed for up to 25 new or 'important' past records of the species. No rationale for identifying the importance of past records is provided. The cited rationale for the SPZ (Semlitsch and Bodie 2003; Lemckert 2004b) is not based upon any scientific evidence of adequacy for the protection of *L. littlejohni*. Furthermore, this approach biases protection measures to places where the species is found, rather than to areas of important habitat or important populations (e.g. it does not provide any protection to non-breeding habitats for the species).

The Action Statement identifies pre-coupe surveys (as per Powell and Sedunary 2013) to ascertain the presence of *L. littlejohni*; however, this approach has a high probability of not detecting the species when it is actually present because they do not target surveys during optimum conditions for the species and have not validated the adequacy of sampling methods. This arcane *ad hoc* approach to threatened species management was adopted for the threatened Long-footed Potoroo *Potorous longipes*, and other threatened species in Victoria 25 years ago (e.g. DCNR 1995), but has been discredited for the above reasons (e.g. Lindenmayer and Burgman 2005). Ironically, implementation of a systematic survey for *L. littlejohni* as a high priority, and undertaking habitat modelling similar to that employed for the Long-footed Potoroo, would enable the development of plans for targeted protection of core habitat within both protected and production areas, and hence negate the need for the creation of *ad hoc* and ineffective SPZs.

Despite recognising the criticality of protecting important habitat for the species, the Action Statement, along with Powell and Sedunary (2013), downplays threats posed by timber harvesting, which is arguably the most severe threat to the species' habitat. The Action Statement suggests that pre-logging surveys created an over-representation of records in timber harvesting areas; however, many pre-logging surveys also included parts of national parks, either existing or created later (e.g. Westaway *et al.* 1990; Opie *et al.* 1990; Lobert *et al.* 1991), and generated records in those parks as well. In the meantime, the Victorian Government has persevered with plans to log most of the remaining stands of old growth and commercially viable wet and damp forests in East Gippsland (Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee 2013), the most likely refugia of *L. littlejohni*. Recovery of declining species can occur only if there is habitat to recover in, and high-quality habitat provides the best recovery potential (Scheele *et al.* 2014a). Therefore there is serious doubt that obligations set out under the *Flora and Fauna Guarantee Act* for the conservation of *L. littlejohni* will be fulfilled.

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The giant cuttlefish *Sepia apama* Gray, 1849 (Cephalopoda: Sepiidae) —an intertidal record of a molluscan marvel

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Abstract

A sighting of a giant cuttlefish *Sepia apama* Gray, 1849 in the lower littoral zone at Merricks Beach, Westernport Bay, Victoria, is reported, and a brief overview of the species, with reference to general cephalopod biology, is provided. (*The Victorian Naturalist* 133 (4), 2016, 139–144)

Key words: Cephalopod biology, intertidal, sepion, southern Australia

Introduction

The giant cuttlefish *Sepia apama* Gray, 1849 is the largest cuttlefish in the world, approaching a weight of 5 kg (Okutani 2015), mantle (or main body) length of 500 mm and total length of 100 cm when fully grown (Norman 2000). It is found along the southern Australian coastline from Brisbane, Queensland, to Shark Bay, Western Australia, and around Tasmania (Norman 2000), to depths of 100 metres (Okutani 2015; Reid 2016). Being active during the day (Norman 2000), common, highly intelligent and curious, it is often encountered by divers. Beachgoers are familiar with its cuttlebone, which is frequently washed ashore along its range. However, the Marine Research Group (MRG) of the Field Naturalists Club of Victoria was recently fortunate to record a living specimen in the intertidal zone, trapped by a very low tide in a large, lower littoral pool. This exciting and extremely rare intertidal encounter has prompted a formal report on the sighting and also an overview of the biology of this species and of cephalopods more generally.

Observations

A single animal (Fig. 1) was observed at Merricks Beach, Westernport Bay, on Saturday 8 March 2014, in a very large, lower littoral pool bordered by rocky reef to the north and east, with its southern end composed of sandy bottom bearing a large bed of the seagrass *Amphibolis antarctica*.

The animal was estimated to be in the order of 250–300 mm from tip of mantle to tip of arms and was gliding calmly within the pool. Sometimes it paused, changed colour and raised papillae on its mantle before gently moving off again. The mantle was always held in the horizontal plane. Observing MRG members standing discreetly in a line along the edge of the pool did not alarm the cuttlefish, which swam quite closely by, to and fro, each pass happily exercising the cameras of all present. It engaged members in this manner for some time before it was left to the peace of its pool and the safe, welcoming embrace of the incoming tide.

General structure and biology

The cuttlefish body consists of a somewhat dorso-ventrally flattened mantle (the main body) containing the cuttlebone (or sepion) and viscera, a head bearing large, highly developed eyes and a mouth surrounded by eight sucker-lined arms. In *Sepia apama* the head has characteristic 'twin rows of three flap-like papillae above each eye' (Adam 1966; Norman and Reid 2000; for illustrations see Lu 1998b Fig. 13.2 D; Figs 1E–H herein) and each arm bears four rows of unequal suckers (Cotton and Godfrey 1940). Arm pairs are numbered taxonomically from dorsal to ventral (Norman 2000) and between the third and fourth pairs is a pair of feeding tentacles (also present in squid). The tentacles have a club-shaped terminal process lined with suckers; when not in use, they can be retracted into a pouch below each eye (Zeidler and Norris 1989). The tentacular clubs of *S. apama* possess five rows of suckers (the middle row largest), the horny rims of which bear short teeth (as do those on the arms) (Cotton and Godfrey 1940). The tentacles are shot out rapidly to capture quarry (Zeidler and Norris 1989; Norman 2000) which is then drawn to the arms and mouth, the opening of which bears a black

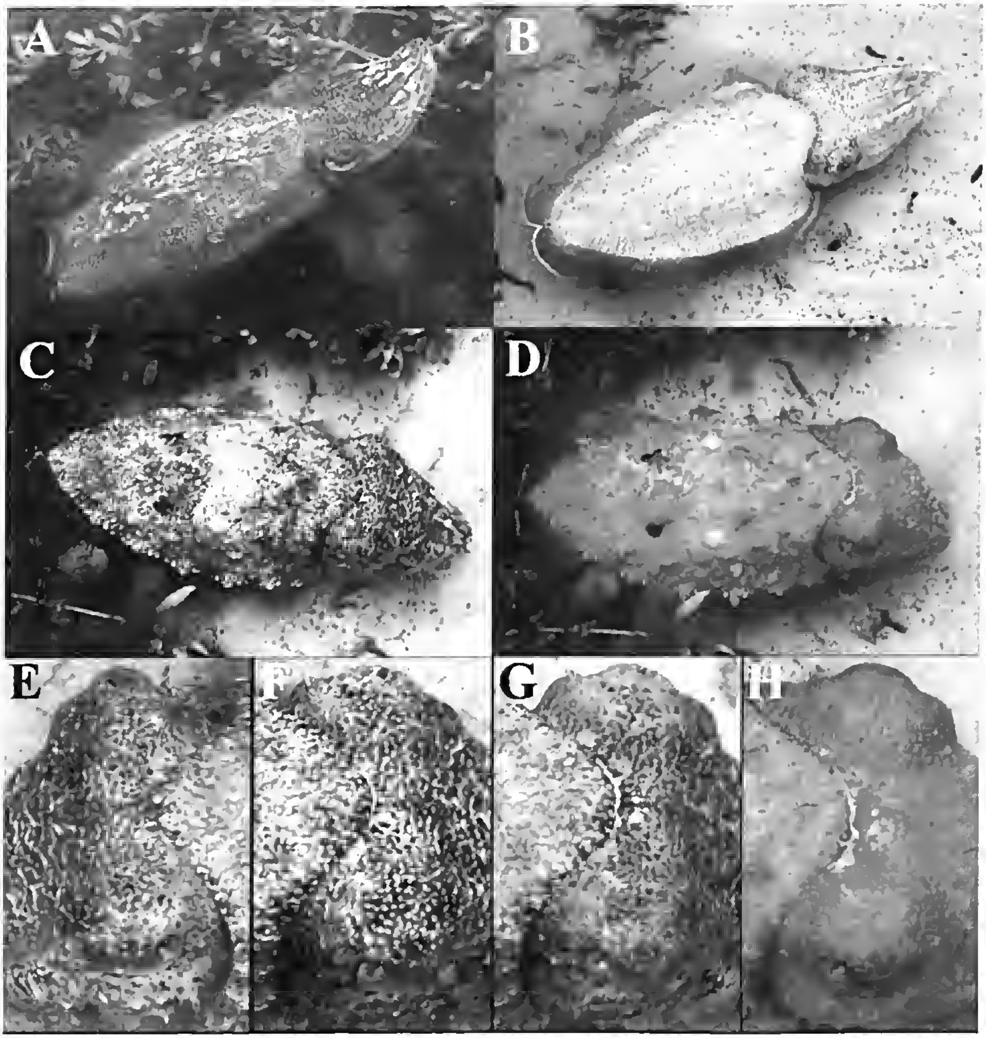

Fig. 1: *Sepia apama* in the intertidal zone at Merricks Beach, Westernport Bay, Victoria, 8 March 2014. All images depict the same animal. **A.** swimming over *Amphibolis antarctica* beds; **B.** gliding over sand; **C, D.** exhibiting colour changes and surface papillae whilst stationary. **E-H.** Closer views of papillae above each eye (Photographs: P Vafiadis).

beak to kill and tear flesh off the victim (Cotton and Godfrey 1940). The radula, a toothed rasp inside the mouth, further shreds the food, and is one of the two key features distinguishing the mollusca, the other being the mantle (Solem 1974). Water leaves the mantle cavity via an exhalent funnel which can be used to generate propulsion. An undulating fin around the periphery of the mantle confers stability and manoeuvrability. Cotton and Godfrey (1940: 417–419) provide a detailed description of the swimming action in *Sepia*.

Sepia apama eats fish and crustaceans (Norman 2000) and lives in crevices or caves on rocky reefs (Zeidler and Norris 1989).

The calcareous sepion distinguishes cuttlefish from their close allies the squids. The latter also have eight arms and two feeding tentacles, but instead of a sepion they bear an internal, flattened, corneous, quill-like structure called a 'pen' or gladius (Norman and Reid 2000). This allows the squid body to be more cylindrical and streamlined (although some cuttlefish also possess quite narrow sepions). Octopuses are benthic animals that have eight arms and no feeding tentacles (Norman and Reid 2000); the lack of an internal shell enables them to squeeze into and through the tightest of gaps and crevices, thereby conferring tremendous offensive and defensive advantages.

Most cephalopods produce ink and this is generally used for defensive purposes but can have other functions (see Norman 2000: 101–103). The nervous system and behavioural patterns of cephalopods are highly developed (see Mangold *et al.* 1998; Norman 2000). Other aspects of cephalopod internal structure, biology and ecology can be found in Ruppert and Barnes 1994; Lu 1998a, 1998b; Lu and Dunning 1998; Mangold *et al.*1998; Scott and Kenny 1998; and Norman 2000. Cuttlefish, squid and octopuses are generally short lived, often in the order of one to two years, sometimes approaching four years, with the larger species having longer lifespans (Wood and O'Dor 2000).

The sepion

Identification guides for cuttlefish sepions are provided by Bell and Plant (1977) for Victoria, Zeidler and Norris (1989) for southern Australia, and Norman and Reid (2000) for Australia. The sepion is almost as long as the body and lies dorsal to the viscera. Fig. 2 shows a sepion of *Sepia apama* collected on a beach; sepions of adult *S. apama* lack a distinct posterior terminal spine. The maximum recorded sepion length of *S. apama* is 560 mm (Reid 2016). The lightness, buoyancy and softness of dead sepions is explained by their microstructure: they are an intricate lattice, bearing very many fine laminar layers arranged roughly parallel to the plane of the sepion. Schmidt-Neilsen (1979) and Norman (2000) report that delicate calcareous pillars separate these laminar layers, but in *Sepia apama* this appears to be achieved by a radial arrangement of closely spaced septae running perpendicular to the laminar layers (Fig. 2). The sepion is thus composed of very many hollow spaces. In life, a combination of liquid and gas fills the compartments, adjusted by the animal to create neutral buoyancy and thus conferring an ability to occupy a range of depths (Schmidt-Nielsen 1979; Norman 2000). The fluid in a living sepion is hypo-osmotic to sea water; water thus moves out into the surrounding tissues, allowing gas to diffuse in to replace it; the gas is mostly nitrogen, under a low pressure of approximately 0.8 atmospheres, with a small amount of oxygen (Schmidt-Nielsen 1979). Without such a system of buoyancy, the dense muscular body would make the animal sink (Norman 2000).

The osmotic movement of water out of the sepion is opposed by the surrounding hydrostatic pressure; the higher the latter (i.e. the greater the depth), the greater the opposition to the osmotic gradient (Schmidt-Neilsen 1979). In one estimate for cuttlefish, this threshold occurs at an external pressure of 24 atmospheres, equating to a depth of approximately 240 metres (Schmidt-Neilsen 1979). The other depth-limiting factor is the physical strength of the sepion (Schmidt-Neilsen 1979; Norman 2000). Different cuttlebones implode under the hydrostatic pressure at depths between 200 and 600 m (Norman 2000).

Bell (1979a) showed that the average sepion lengths of beached *S. apama* in Victoria varied on a monthly basis, with progressive average sizes increasing from December through to November (by about 10 mm per month), followed by a sudden fall from November to December. This suggested that hatching in this region occurred in November/December (Bell 1979a). Cotton and Godfrey (1940) collected egg cases on beaches after storms in October and November. Norman (2000) states that this species breeds and spawns from May to September. Based on a study of width to length ratios, Bell (1979a, b) considered *S. apama* to be mature when the sepion length reached 100 mm (equating to an age of 10 to12 months based on growth estimates). Given this, the Merricks beach specimen was most likely adult. The largest sepion found by Bell (1979a) was 460 mm long, suggesting an age close to four years if regular growth rates are assumed. This study, however, did not directly consider other important growth-rate variables such as water temperature and food availability (Hall

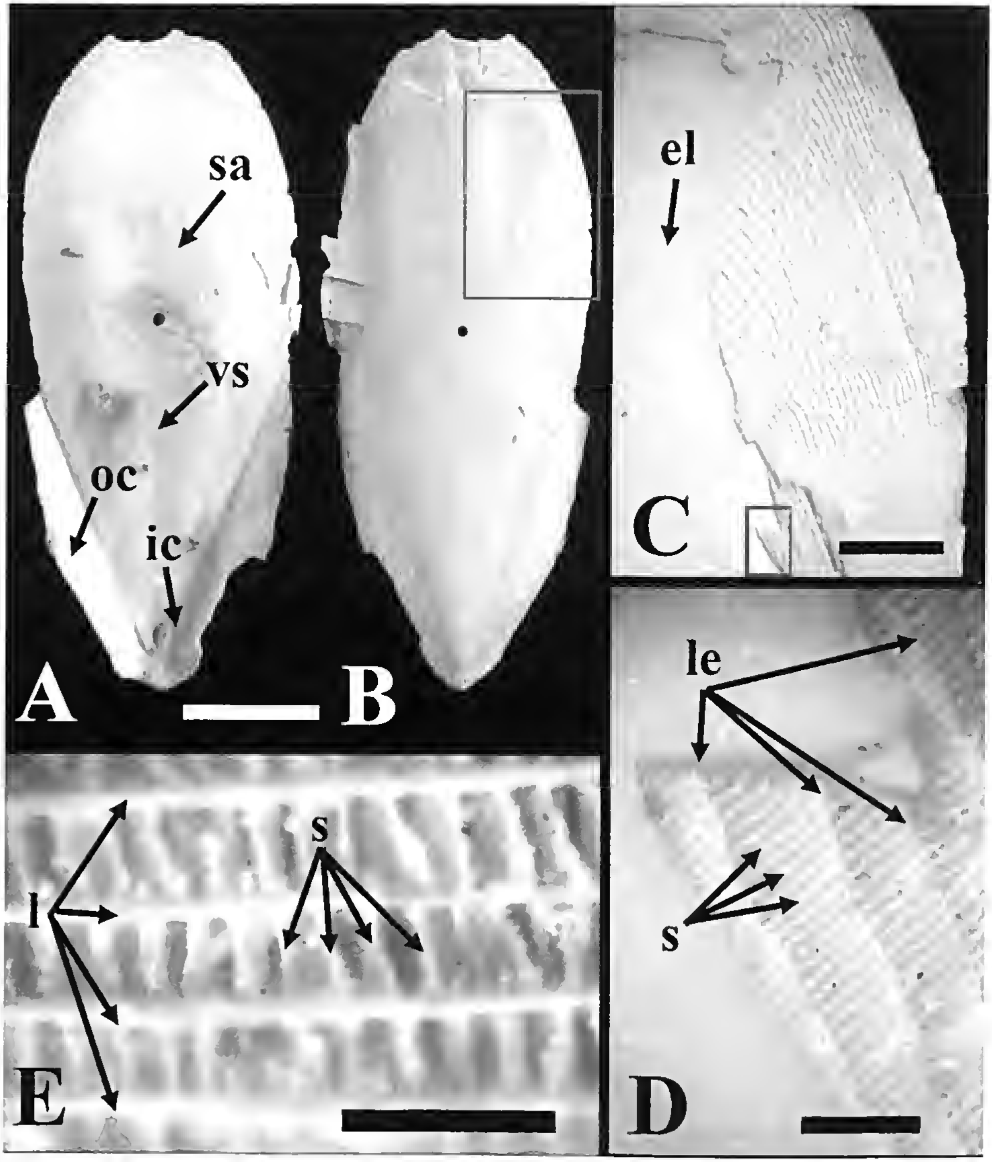

Fig. 2. A sepion (or cuttlebone) of *Sepia apama* from Victoria. **A, B.** ventral and dorsal views, respectively (anterior end is uppermost); **C.** enlargement of marked area in B, with detail of dorsal surface revealed by partial loss of external layer; **D, E.** close-up views, dorsal (enlargement of marked area in C) and side-on, respectively. Key: **el** – external layer, **ic** – inner cone, **l** – laminæ, **le** – laminar edges, **oc** – outer cone, **s** – septæ, **sa** – striated area; **vs** – ventral sulcus. **Scale bars: A, B.** 40 mm; **C.** 10 mm ; **D.** 1.0 mm; **E.** approximately 0.5 mm. (Sepion in the author's collection; photographs P Vafiadis).

et al. 2007), which can vary across seasons and thus confound age estimates. Rather than total sepion length, Hall *et al.* (2007) noted that it was growth increment patterns in the sepion microsculpture of *S. apama* that showed seasonal variation, allowing them to be used to assess age. Accordingly, *S. apama* has an estimated lifespan of up to two years (Hall *et* *al.* 2007) (see also the discussion below under reproduction and mating behaviour).

Some cephalopods also use a gas-containing shell in a similar manner to cuttlefish to maintain neutral buoyancy. *Nautilus* has a strong external shell with gas-containing chambers (the gas always at a pressure of less than one atmosphere), linked by a communicating channel called the siphuncule, with the animal occupying the largest last chamber (Schmidt-Neilsen 1979; Norman 2000). The Ram's horn squid *Spirula spirula* also has a small, partially internalised, chambered shell that functions in much the same way. The greater shell rigidity means that the depth range of these groups usually exceeds that of cuttlefish—the *Nautilus* shell will implode at around 750 m, and *Spirula* at about 1000 m (Norman 2000).

Lacking a chambered shell, squids cannot maintain neutral buoyancy and must constantly swim to remain suspended in the water column, but this energy cost is compensated by a streamlined agility conferring predatory efficiency (Norman 2000). Nevertheless, there are examples of squid species using stores of ammonium chloride solution or fatty oils (both less dense than seawater) to confer buoyancy (Norman 2000). Octopuses also lack an internal buoyancy system and, although they swim, most are confined to a life on the benthos. However, even within this group there are exceptions, with one species having a gas-filled bladder that enables it to live as a free-swimming animal in surface waters (see Norman 2000: 41).

Colour changes, camouflage and vision

The cephalopod dermis contains chromatophores (pigment cells) in densities of up to hundreds per square mm (Norman 2000), arranged in groups or layers (Ruppert and Barnes 1994). Each chromatophore stores pigment of a particular colour and can be broadly and flatly expanded (enhancing its colour) or greatly contracted (minimising its colour) via voluntary muscle cells (Ruppert and Barnes 1994; Norman 2000). The dermis also contains leucophores (cells which scatter light to produce white colouration [Norman 2000]), and, in the deeper layers, iridophores (cells that reflect light to produce an iridescent hue) (Ruppert and Barnes 1994; Norman 2000). Cephalopods, especially cuttlefish, are thus capable of a bewildering and unrivalled camouflage ability, rapid colour change and complex pattern displays. Bioluminescence is also a capability present especially in deep water squid species (see Norman 2000 for detailed discussion).

To assist camouflage, *Sepia apama* (like many cephalopods) can also change its surface texture via dermal muscle fibres, raising complex papillae to mimic and blend in with surrounding surfaces such as algal growth (Norman 2000).

Despite the presence of excellent visual acuity in most species, cephalopods do not see in colour (Norman 2000: 82–84), a remarkable fact given their outstanding camouflage ability.

Reproduction and mating behaviour

Breeding in *Sepia apama* is well documented through study of annual winter mass-spawning aggregations that occur on shallow rocky reefs at northern Spencer Gulf, South Australia (Norman *et al.* 1999; Hall and Hanlon 2002; Naud *et al.* 2004; Hall *et al.* 2007). Here, males flash courtship displays consisting of rippling dark bands along the body (Norman *et al.* 1999). In these aggregations, males outnumber females by at least four times (Hall and Hanlon 2002), both males and females seek and receive multiple mates (Hall and Hanlon 2002) and female egg clusters show multiple paternity (Naud *et al.* 2004). Mating occurs head to head, the male transferring a spermatophore package to the female. Males aggressively defend their chosen female from other males (Norman *et al.* 1999; Hall and Hanlon 2002). In the presence of larger males, smaller males assume female colour patterns, allowing them to approach guarded females without being perceived as a threat by the attending male. While the attending male is otherwise engaged in warding off rivals, the disguised male then successfully moves in and breeds (Norman *et al.* 1999; Hall and Hanlon 2002).

Sepion microsculpture growth increment patterns from these breeding aggregations suggest two distinct lifecycles in northern Spencer Gulf. Most animals show rapid growth (within eight months) and breed as small adults within the first mating season post-hatching, whilst others grow slowly in the first year and breed as larger adults in the second mating season post-hatching (Hall *et al.* 2007). Analysis of microsculpture growth patterns from the sampling of breeding individuals over three consecutive winters showed no evidence that either cohort returned to breed in the following year, suggesting that *S. apama* is semelparous (that is, it breeds only once and then dies) (Hall *et al.* 2007). Lu (1998b) notes that semelparity is often the case with cuttlefish, squid and octopuses, although there are exceptions across each of these groups (see Mangold *et al.* 1998: 470–471).

The egg capsules of *Sepia apama* are white and stalked, total length up to 60 mm (Cotton and Godfrey 1940) with the ovoid body about 30 mm long (Cotton and Godfrey 1940; Smith *et al.* 1989). Capsules are laid one at a time in groups attached to crevices or the roof of rocky caves, each bearing a single egg (Hall and Hanlon 2002; Smith *et al.* 1989). After three to five months (Hall and Hanlon 2002), a swimming hatchling emerges from the capsule (Smith *et al.* 1989).

Concluding thoughts

We are fortunate to have this remarkable animal living in our coastal waters. The giant cuttlefish, like all of its cephalopod relatives, is a molluscan marvel that demonstrates the extraordinary complexity of invertebrate animals. Although common subtidally, its encounter in the intertidal zone was a first for the gathered MRG members and an occasion that all will remember and treasure.

Acknowledgements

I thank Anne Morton (FNCV) for her encouragement with this article; Amanda Reid (Australian Museum, Sydney) for valued advice; Robert Burn (MRG) for interesting discussion, and the paper by W Adam; Robin Wilson (Museum Victoria) for assistance with reference material; and Evlambia Vafiadis for help with the figures. I also thank an anonymous referee for helpful suggestions and comments that have greatly improved the manuscript.

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First record of the Broad-shelled River Turtle *Chelodina expansa* Gray, 1857 (Testudines: Chelidae) from the Castlereagh River in northern inland New South Wales, with notes on nesting

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Abstract
This paper describes the first documented record of the Broad-shelled River Turtle *Chelodina expansa* Gray, 1857 in the Castlereagh River catchment, New South Wales, filling a gap in the known distribution of the species. A nesting event is described, with the clutch size of 23 eggs towards the upper end of the range recorded for this species. (*The Victorian Naturalist* 133 (4), 2016, 145–148)

Key Words: *Chelodina expansa*, Castlereagh River, reproduction, oviposition

Introduction

The Broad-shelled River Turtle *Chelodina expansa* Gray, 1857 (Fig. 1) is one of Australia's largest side-necked turtle species, with a distribution ranging from coastal and inland south-eastern Queensland and the New South Wales (NSW) far north coast through inland NSW and Victoria to south-eastern South Australia (Cogger 2014). In northern inland NSW it is known from the Macintyre-Dumaresq, Namoi, Gwydir and Macquarie river systems of the Murray-Darling Basin (Swan *et al.* 2004; Bower and Hodges 2014; Atlas of Living Australia; Atlas of NSW Wildlife). This contribution documents a recent record of *C. expansa* from the upper Castlereagh River in the Murray-Darling Basin and constitutes the first documented record from this river. The Castlereagh River has a catchment area of about 17 400 km², originating in the Warrumbungle Ranges near Coonabarabran in Gamilaraay Aboriginal Country, and flowing south and then north-west for about 550 km to join the lower Macquarie River downstream of the Macquarie Marshes (NSW Department of Primary Industries, undated).

Observations

Two female *C. expansa* were opportunistically observed in a riverside urban park on the upper Castlereagh River immediately upstream of the Newell Highway bridge at Coonabarabran (31°16.33'S, 149°16.55'E) (elevation 500 m Australian Height Datum) at around midday on 14 May 2013. The two animals were out of the water at the same time.

Identification of the turtles as *Chelodina expansa* was indicated by the large body size

Fig. 1. Broad-shelled River Turtle, Castlereagh River, Coonabarabran. Photo MJ Murphy.

and was confirmed by the following set of diagnostic features on the shell (Cogger 2014): plastron (lower shell) with gular shields in contact in front of the intergular shield, intergular shield scarcely longer than the suture between the pectoral shields, and absence of black edging to the plastron sutures; carapace (upper shell) with second and third vertebral shields longer than wide. The section of river where the turtles were found (Fig. 2) comprises a long slow-flowing permanent weir pool sparsely bordered by River Oak *Casuarina cunninghamiana* and Weeping Willow *Salix babylonica*, with one concrete weir located 800 m upstream and another 1100 m downstream. The river at this location is about 10 to 12 m wide and has a muddy bottom and generally turbid water. Weather conditions at the time of observation were cloudy but dry, following about 23 mm of rain overnight and the previous day. This had

Fig. 2. Castlereagh River at Coonabarabran, viewed from the Newell Highway bridge. The footpath along the edge of the high bank where turtle 1 was found is in the mid-ground and the low knoll where turtle 2 was found nesting is located left background. Photo MJ Murphy.

been the first local rain event for about seven weeks.

Turtle 1 was found next to a footpath along the inner margin of a grassed high bank about 20 m from and 4 m above the river's edge (see Fig. 2). The animal was handled to confirm identification and for measurement (using a flexible tape with 0.5 cm markings) and was then released away from the path. The carapace had a straight length of 390 mm and maximum width of 280 mm. After release, the turtle moved to a location further along the edge of the high bank (about 25 m from and 4 m above the river's edge), where it attempted to excavate a nesting hole in alluvial soil but was attacked by ants disturbed by the digging and abandoned the effort, returning to the river. The partly excavated hole measured approximately 140 mm deep and 80 mm wide.

Turtle 2 (Fig. 3) was found excavating a nesting hole on top of a low grassed knoll about 6 m higher than the nearby river, being the highest point in the immediate area, at a distance of about 70 m from the river's edge and about 50 m from the attempted nesting site of turtle 1. This knoll (see Fig. 2) was situated approximately 10 m from the closest building and about 45 m from the rear of a large supermarket building (Fig. 4). The hole was dug using the back legs alternately to remove soil. After each egg was laid, a hind foot (again alternating between left and

Fig. 3. Broad-shelled River Turtle at nest. Photo MJ Murphy.

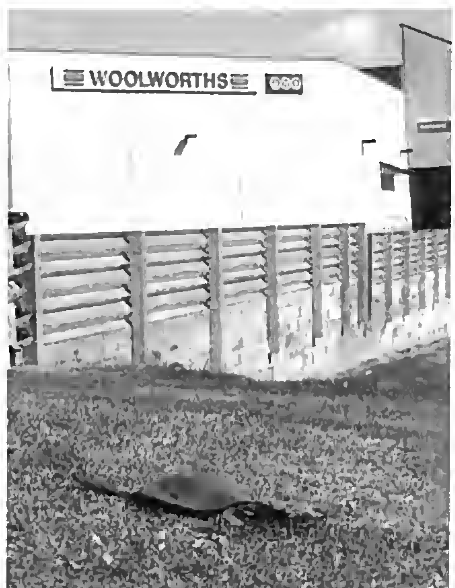

Fig. 4. Nesting Broad-shelled River Turtle in close proximity to buildings. Photo MJ Murphy.

right) was used to move the egg into a closely-packed position. Egg laying extended over approximately 30 minutes and, on completion, the hind legs were used to pull soil back over the eggs and the animal then returned to the river. The animal was measured after departure from the nest and had a straight carapace length of 360 mm and maximum width of 275 mm. The nest was then inspected and contained 23 eggs buried > 60 mm below the ground surface in moist alluvial soil, in a flask-shaped chamber 150 mm deep by 120 mm wide (Fig. 5). The nest chamber had water at the bottom. The size of six randomly selected eggs was estimated (using a metal ruler with 1 mm markings), and had a mean size of 41.5 mm x 28 mm (range 39–43 mm x 27–29 mm). The eggs were returned to the nest and reburied.

Discussion

The present record fills a gap in the known distribution of *C. expansa*, which is already known from the adjacent catchments to the north-east (Namoi River) and south-west (Macquarie River) but had not previously been recorded from

Fig. 5. Broad-shelled River Turtle nest exposed showing eggs. Photo MJ Murphy.

the Castlereagh River catchment (Swan *et al.* 2004; Bower and Hodges 2014; Atlas of Living Australia; Atlas of NSW Wildlife). The record has been added to the Atlas of NSW Wildlife. Despite its large size, *C. expansa* is a cryptic species (Legler 1978; Georges 1984; Spencer and Thompson 2005; Bower and Hodges 2014) and may therefore easily go undetected in an area. The author had been resident in Coonabarabran for seven years prior to the opportunistic observations reported here and had not previously observed the species in the area. *Chelodina expansa* can show a high degree of fidelity to specific sections of river but is also capable of extensive movements of up to 25 km along rivers (Bower *et al.* 2012; Howard *et al.* 2013). The observation of two breeding females at Coonabarabran suggests there is a resident population in the upper Castlereagh River.

The nesting behaviour by *C. expansa* documented here is consistent with previous descriptions for this species, including time of year, time of day, weather conditions, nest location and clutch size. Unlike other Australian temperate zone turtle species, nesting by *C. expansa* usually occurs in autumn or winter (Goode 1965; Georges 1984; Booth 1998, 2002, 2010). Georges (1984) noted that the nesting season of *C. expansa* was more typical of tropical wet/dry seasonal cycles and conjectured that the species might have originated in tropical northern Australia and have only recently arrived in temperate southern Australia. Nesting by *C. expansa* occurs during daylight hours and is often associated with moderate to heavy rain (Georges 1984; McCosker 2002; Bowen *et al.* 2005; Booth 2010). Females travel a considerable distance from the water (sometimes hundreds of metres) and nest sites are typically located on higher ground (Georges 1984; Booth 2010). The species is tolerant of human proximity when nesting (Booth 2010). The clutch size of 23 eggs reported here is at the upper end of the 9–23 range recorded for *C. expansa* in south-east Queensland (Georges 1984; Booth 1998, 2010) and towards the upper end of the 5–25 range recorded for the species in northern Victoria (Goode and Russell 1968). Booth (1998) noted the most common clutch size was 14–16 eggs and Goode and Russell (1968) reported an average clutch size of 15.4 eggs. Use of the rear legs to excavate the nest cavity, reposition the eggs and backfill the nest as described here is a common behaviour shared with other Australian side-necked turtles including Eastern Snake-necked Turtle *Chelodina longicollis*, Macquarie Turtle *Emydura macquarii* and Irwin's Snapping Turtle *Elseya irwini* (Green 1996, 1997; Turner 2004), and is similar to the nesting behaviour of many other turtle species including marine turtles (Miller *et al.* 2003).

Chelodina expansa was assessed as 'rare or insufficiently known' and potentially threatened in a national review of the status of Australian reptiles (Cogger *et al.* 1993). The species is not currently listed as a species of conservation concern under Commonwealth legislation (*Environment Protection and Biodiversity Conservation Act 1999*), or state legislation in NSW (*Threatened Species Conservation Act 1995*) or Queensland (*Nature Conservation Act 1992*), but is listed as Threatened in Victoria (*Flora and Fauna Guarantee Act 1988*) and Vulnerable in South Australia (*National Parks and Wildlife Act 1972*). The Murray-Darling Basin is suffering an ongoing decline in environmental conditions, which is threatening aquatic ecosystems (LeBlanc *et al.* 2012). Reliance on climatic cues for reproduction may make *C. expansa* particularly susceptible to future decline due to anthropogenic climate change (Bower and Hodges 2014). The observations documented here contribute to the knowledge base concerning this cryptic species.

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Frogs heard in the Blackburn Creeklands 1971–2015

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Abstract
Recordings of frog calls made in the Melbourne suburb of Blackburn, Victoria, in 1971–1972 were identified and compared with calls heard in the same area in 2015. Although five species were heard in 1971–1972, only three were heard in 2015. *Litoria ewingii* and *Limnodynastes tasmaniensis* were present in both years, while three species *Crinia signifera, Geocrinia victoriana* and *Limnodynastes dumerilii* had disappeared by 2015. One additional species; *Limnodynastes peronii*, was present in 2015. The area has been extensively revegetated since 1971 and is now managed by the local Council as an urban bushland park, the Blackburn Creeklands. (*The Victorian Naturalist* 133 (4), 2016, 149–152)

Keywords: Amphibia, urbanisation, ecology, species occurrence

A number of studies in Melbourne, Victoria, have shown a reduction in frog diversity with urbanisation (Parris 2006; Hamer and McDonnell 2010; Hamer 2011; Hamer *et al.* 2012). In light of these studies, we compared species heard calling in 1971–1972 with calls heard in the same area in 2015. The opportunity to make this comparison arose when a series of recordings of frog calls made by one of us (John Osborn) in 1971–1972 was found to be in excellent condition with species able to be identified. John made the recordings in an area now part of the Blackburn Creeklands bush park in suburban Melbourne, 16 km east of the city centre. The park runs along either side of a permanently flowing tributary of Gardiners Creek (Fig. 1). In the early 1970s, prior to the creation of the park, there were a series of shallow swampy depressions to the south of the creek that held water for long periods and from which frogs were regularly heard calling. There were grassy weeds and unidentified bushes around these depressions with remnant vegetation nearby along the creek edge. John remembers one frog species also calling from the creek. The depressions were filled in during the mid 1970s and replaced by mown grass. However, although the original frog habitat is gone, there is a large population of frogs in a restored billabong a short distance north of the creek (Fig. 1). This billabong is filled with runoff from nearby roads and, although ephemeral, holds water for much of the year.

Throughout 2015, a record was made of frogs heard in the billabong as well as in the creek. Results are shown in Table 1.

Only three species were heard in 2015, with two species, *Litoria ewingii* (Fig. 2) and *Limnodynastes tasmaniensis*, still in the area after over 40 years. Three species are no longer present and one additional species has arrived.

One species that has persisted, *L. ewingii* is a known 'urban adapter' (McKinney 2002), successfully using artificial water bodies in suburbia as habitat (Parris 2006). We heard it in both 1971–72 and 2015 in temporary water bodies adjacent to the creek and also in garden ponds outside the park.

The second persisting species, *L. tasmaniensis* was heard calling only occasionally from the billabong after it had been freshly filled with rain following a long dry spell in November 2015. It prefers swampy shallower conditions with a cover of emergent vegetation (Hamer *et al.* 2012). Both the depressions in 1971–72, and the restored northern billabong (Fig. 3) where calls were heard in 2015, dry out over summer, so it must be assumed that there is sufficient moisture retained at the base of the thick vegetation covering the two water bodies for the adult frogs to survive. The creek is never dry so it is possible that the frogs move closer to the creek in dry times.

Limnodynastes peronii was present in 2015 but not 1971–72, a finding consistent with previous studies that found a big increase in

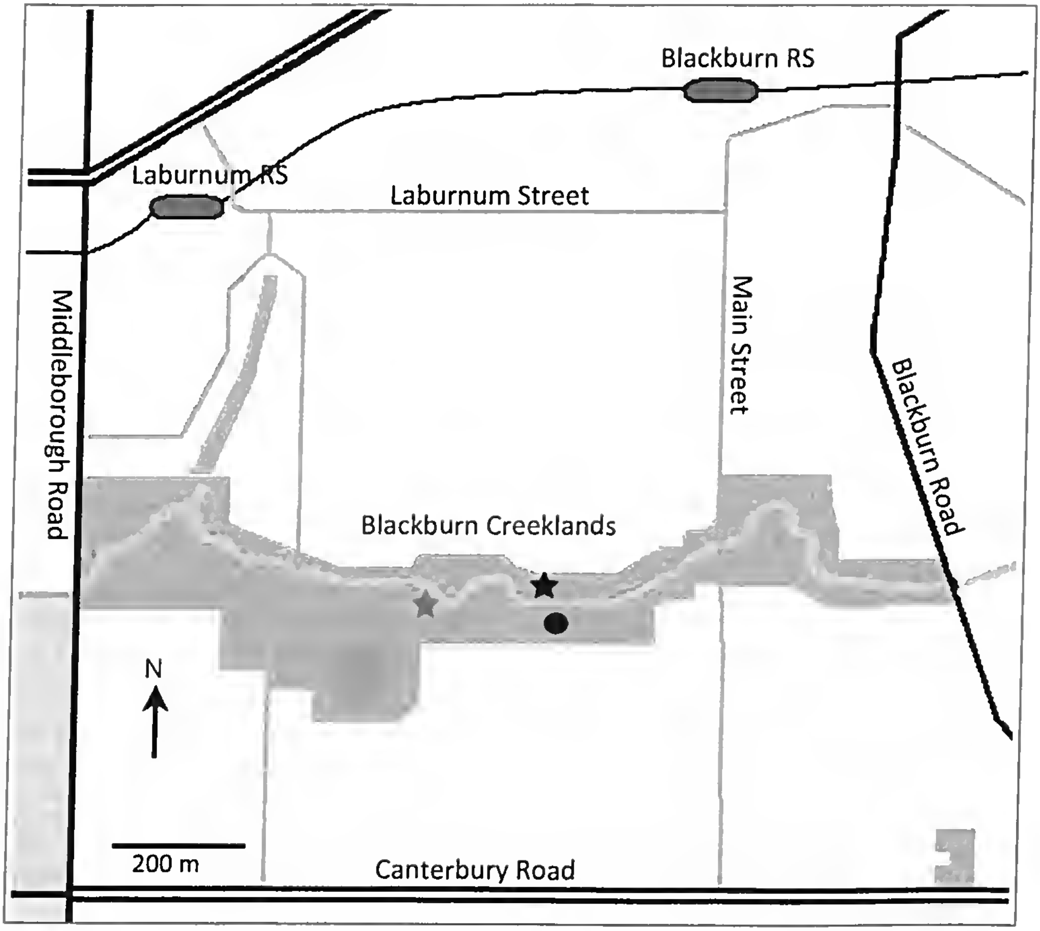

Fig. 1. The location of the Blackburn Creeklands park in Blackburn. The creek is a tributary of Gardiners Creek. Green areas are parkland, with the remainder of the area housing and roads. Symbols are: site of 1971–72 recordings, black dot; site of frog calls in 2015 (northern billabong), black star; site of new wetlands (southern billabong) developed in 2015, red star.

the spread of this species in urban Melbourne (Hamer 2011). It appears to thrive in disturbed and degraded habitats, with its high fecundity assisting its spread and abundance (Schell and Burgin 2003, Hengl and Burgin 2002). The creek and riparian vegetation provides a likely corridor for its movement through suburbia. Frog census records show that it had arrived in Blackburn South by 2001 (http://frogs.melbournewater.com.au). John recollects sightings of this species in the late 1970s adjacent to the area where his recordings were made. It was the only species heard calling in every month throughout 2015.

The disappearance of *Geocrinia victoriana* is consistent with its characterisation as 'urban sensitive' (Hamer and McDonnell 2010), and Hamer (2011) did not record it in his study of frogs of urban areas of Melbourne. It is surprising that it was still present in 1971–72 as it is a forest-dwelling species, living and breeding in moist litter adjacent to ponds that will later flood to provide an aquatic habitat for the tadpoles (Littlejohn 1963). In 1971–72, the area

Table 1. Frog species recorded calling in the Blackburn Creeklands in 1971–72 and 2015.

Species	Common name	Heard in 1971–72	Heard in 2015
Limnodynastes tasmaniensis	Spotted Marsh Frog	Yes	Yes
Litoria ewingii	Southern Brown Tree Frog	Yes	Yes
Geocrinia victoriana	Victorian Smooth Froglet	Yes	No
Crinia signifera	Common Froglet	Yes	No
Limnodynastes dumerilii	Southern Bullfrog	Yes (and in creek)	No
Limnodynastes peronii	Striped Marsh Frog	No	Yes

was not managed as a park so possibly litter beneath remnant eucalypts and acacias was thick and undisturbed.

The disappearance of *Crinia signifera*, however, is less expected as it is widespread throughout urban Melbourne (Hamer 2011, Hamer and McDonnell 2010) with Hamer *et al.* (2012) finding it at 90% of ponds visited.

The absence of *Limnodynastes dumerilii* is also quite surprising, especially as Larwill (1995) found that *L. dumerilii* was common in the Melbourne area in 1994 while *L. peronii* was uncommon. *Limnodynastes dumerilii* prefers deeper water bodies (Hamer *et al.* 2012) so the conditions may not have suited it in the relatively shallow billabong. In a long-term study of frogs in Canberra, Westgate *et al.* (2015) also found *L. dumerilii* was less likely to occur in still water than other species. It is possible that small numbers of this species may still be living along the creek where there are occasional deeper sections, and have simply missed being heard despite daily visits to the creek and billabong. It was heard calling on one occasion at nearby Blackburn Lake (September 20, 2015). On all other occasions, *L. peronii* was the only species calling from this location.

In a study of recolonisation of rehabilitated mining sites in New South Wales, Letnic and Fox (1997) found that frogs showed a successional pattern of species replacement with *L. dumerilii* present only in the earlier years of rehabilitation when vegetation was sparser, while *L. peronii* occurred in abundance in later years. It is possible that changes in vegetation and its management, since the land in this study became bush parkland, have favoured *L. peronii* and disadvantaged *L. dumerilii*.

Fig. 2. Southern Brown Tree Frog *Litoria ewingii*. Photo by Ian Moodie.

What future do frogs have in urban areas such as Blackburn? The area, like much of suburban Melbourne, is being more intensively developed with large quarter-acre housing blocks becoming rarer. Those housing blocks not subdivided tend now to be occupied by larger houses with manicured gardens not conducive to supporting frogs. With an increasing human population, parkland is becoming busier and more intensively used, creating extra pressures on wetlands and remnant vegetation.

Fig. 3. Billabong north of the creek where frogs were heard calling in 2015.

Fig. 4. Billabong south of the creek in the process of restoration.

The creek through the Blackburn Creeklands has intermittent very high flows due to increased hard-surfacing and more stormwater drains. This has led to erosion control measures to change the natural contours of the creek edges. However, the creek is still vital as a corridor and a dry-weather refuge for frogs. Fortunately, the local Council and community appear to value the bushland habitat retained or being restored along the creek, and recognise the need for appropriately managed wetland habitats. Ponds need to have emergent vegetation in them, as well as undisturbed areas of bushes and unmown long grass around them. In May 2015, stormwater was diverted to fill a former dry billabong on the south side of the creek (Figs 1 and 4) in the Blackburn Creeklands. The surrounds are currently being revegetated and, once plants have become established, this may be expected to provide further habitat for frogs. We plan to continue to monitor the frog population and hope we shall continue to hear not only the frogs currently present but perhaps more species in years to come.

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Places, people and events

A reading on the 20th anniversary of the opening of the FNCV premises in Blackburn, 8 July 2016

I have just finished reading Tim Winton's memoir, *Island Home*, in which he describes the special places, inspiring people and memorable events that have influenced his writing about Australia and his own philosophy on its conservation.

I briefly would like to do the same.

A backyard in Blackburn

The first special place is my parents' backyard in Laburnum Street, Blackburn, where my real interest in natural history observation and recording began. The memorable event that inspired me was the discovery of a White-browed Scrubwren *Sericornis frontalis* nesting at the base of a glory vine by our side fence in 1954. I took my excitement back to Poowong Primary School, where I was teaching at the time, and shared it with my Grades 3 and 4 children in a little newsletter called *Blackburn Birdbook*. I also made contact with Jack Hyett, a famous naturalist, teaching then at nearby Nyora township, and began collecting roadkill birds to sketch. Back home in Blackburn each weekend, I would also sketch the flowers, berries and insects on our garden shrubs. Gang-gang Cockatoos were coming in to feed on our crabapple berries and the now rare Regent Honeyeaters were nesting in the trees there. It was at Poowong that I saw my first Giant Earthworm and began, in the *Korumburra Times*, the first of my regular regional news columns.

Barongarook Creek

My next special place is the Barongarook Creek, where it flows into Lake Colac. Back teaching art and craft in my home town of Colac, I joined with Dr Graham Browne, Pauline Reilly and Murray Hodges to form the Colac Field Naturalists Club. We invited naturalist/broadcaster, Philip Crosbie Morrison, to launch the club in 1956. There was a huge turn-up of interested people of all ages to hear him speak and I was able to form a junior naturalists group, which met at the Colac West Primary School each month on a Saturday morning, after the senior club's Friday night meeting. They helped me to record the wildlife on the Lake Colac foreshore and band Silver Gulls *Chroicocephalus novæhollandiæ* on lake islands near Beeac. I continued bird-banding studies in many more places over the next 60 years.

One of our guest speakers was senior botanist Dr Jim Willis, who introduced us to the wondrous colours and forms of the Otways fungi. Another highlight of the Colac years was the discovery with Graham of the thought-to-be-extinct Ground Parrot *Pezoporus wallicus* at Chapple Vale.

Somers Children's School Camp

My next special place was the Children's School Camp at Somers, where I taught nature study between 1959 and 1966 and where I met Wendy and we had our first four children. Jack Hyett came as a visiting teacher and opened my eyes to the joys of mammal surveying. Later, whilst teaching Environmental Studies at Burwood Teachers College with Jack, we discovered new populations in the Grampians of the rare Heath Rat *Pseudomys shortridgei*. A family friend, Ron Jensz, then education officer for the National Museum of Victoria, came regularly to Somers with his family and introduced me to the fascinating world of polychaetes along the tidal flats. Other visitors included Bill Davis and Fred Smith, who joined us in the Survey Somers fortnightly bird counts from 1960 to 1966 at Coolart sanctuary and the Flinders Naval Depot's Sandy Point bushland reserve.

Between 1967 and 1973, I was attending Monash University doing a Bachelor of Science degree part-time, and there met Dr Ian Bayly, who encouraged and supervised my studies in freshwater biology. Later, as a resident with me on Flinders Island, Ian showed me the intriguing *gnamma* waterholes there. From 1970 to 1985 I was education officer for the Australian Conservation Foundation and visited many special places around Australia. During these years, visits to Kakadu and Jabiru were highlights, as my son John was teaching science at Jabiru and organised a Wind Festival to celebrate the onset of the next change in the local Aboriginal calendar. The different Aboriginal seasonal calendars around Australia intrigued me, with three to twelve seasons recognised in different bioregions. They confirmed for me the suspicions I formed during my Colac surveys about the inappropriate four season European calendar structure applied across Australia. Other achievements in the 1980s included the founding of the Australian Association for Environmental Education with Professor Peter Fensham as President and an active committee consisting of Peter Biro, Annette Greenall, Marta Hamilton and myself as newsletter editor.

When I was elected President of the Gould League in 1990, we produced *Gumleaves and Geckoes*, a predictive nature diary for south-eastern Australia, which included simple monitoring and recording techniques. Awarded the 1993 Australian Natural History Medallion, I proposed in my address to the FNCV the formation of a group to look at developing up-to-date seasonal calendars for bioregions across Australia, an idea that was enthusiastically adopted by several groups around Australia. So, the Timelines Project was born, and with seasonal event information coming from all the states, the Gould League produced in 1996, with beautiful illustrations by Alexis Beckett, the *Banksias & Bilbies* nature diary featuring weekly event predictions for habitats in northern and southern Australia. It was the handbook for the Timelines project.

Blackburn Lake

Another special place for me was Blackburn Lake. We lived close by in Alandale Road for 16 years and I regularly walked around the lake, recording wildlife, helping to establish the information centre with Dorothy Meagher, Su Dempsey and Anne Payne, and designing nature trails from the Blackburn Library to the lake. Blackburn Lake information centre was also the site for the launch of the revised Gould League series of the *Birds of South-eastern Australia*, published in honour of my late sister-in-law, Susan McInnes, who was the artist for the seven-book habitat set and many other Gould League publications. It was first published in 1969 with co-authors Roy Wheeler and Noel Shaw. During the 1980s, I joined Cecily Falkingham in establishing nature trails around Nunawading and in producing regular nature articles for the *Nunawading Gazette*. At this time, I was also a guest nature commentator on ABC radio with Elaine Canty and Derek Guille for many years. The *Timelines Australia* newsletter was originally produced for this show, and continues to be produced to this day. My wife Wendy was a Nunawading councillor from 1976 to 1989 and helped to establish the Nunawading Community Gardens Centre, where we had many of our naturalist group meetings.

Timelines field centre

A special place for me during the 1990s was our family-built Timelines field centre at Glenburn, where we had many field days with field naturalist and other environmental groups over several years, and where I completed a 35-year study of our wildlife corridor and the artificial lakes across our family-owned neighbouring Graceburn and Kildun properties.

Flinders Island rock pools

The next special place in my 60-plus years naturalist journey is the set of rock pools by our dining room window at Flinders Island, where Wendy and I now live. Scores of honeyeaters and small insectivorous birds and echidnas visit the pool to drink and bathe. The records of their visits join the number of observations and photos sent by residents and visitors to update the Furneaux Group six-season regional calendar and the monitoring trails pamphlets that we and the Furneaux Historical Research Association created in 2006. Four times a year, I now produce a *Timelines Discovery* newsletter for interested residents, council officers and tourist groups.

Another memorable event of the past 10 years was the award of a Medal of the Order of Australia (OAM). This was presented in 2006 at the special place of Government House and garden in Hobart by the then Governor of Tasmania, The Honourable William Cox AC. My family and old friends Bill and Jill Davis were present.

The last special place is where you're sitting now. The memorable event was 7 July 1996 and the inspiring people are yourselves. Because a large part of my naturalist life has focused on Blackburn, I was thrilled when the FNCV invited me to open the new premises. Here is my journal account of the occasion:

> Thursday, 11 July 1996, 'Kildun', Glenburn
> On Sunday, I travelled down to Blackburn to officially open the new FNCV headquarters at No. 1 Gardenia St. Blackburn. The rooms look excellent —a large hall, a good library room all beautifully set up and a kitchen and offices. More than 120 crowded into the hall, which had been earlier set up with displays by the various active groups. Many old friends were there, including Gwynneth Taylor, Cecily Falkingham, Ailsa and John Swann and Dan McInnes (now 90 and still focusing on his microscopy). Rob Wallis welcomed me warmly and I spoke for almost an hour to my paper, using some overhead transparencies. It was well received and at the end I declared the HQ officially open.

May you long continue with your fabulous study groups and colourful reporting of nature discoveries!

Alan Reid
Flinders Island, Tasmania 7255

Alan Reid (R) pictured with Rob Wallis at the opening of the FNCV Hall, 7 July 1996. Photo Geoffrey Paterson.